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INSTITUTE OF TECHNOLOGY,
BOSTON.

COURSES FOR TEACHERS.



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COURSES FOR TEACHERS.

THE increasing interest in the improvement of secondary education and the introduction of the elements of physical and natural science into the secondary schools are regarded by the Faculty of the Massachusetts Institute of Technology as imposing upon them the duty to extend, as far as possible, to those actually engaged in teaching, the advantages which the central location of the Institute, its highly organized laboratories, and its large corps of instructors offer to persons living in or near Boston.

It has not been thought expedient for this purpose, however, to present disconnected courses of lectures without other requirements than attendance. In order to acquire the spirit of modern scientific work, as well as its methods and subject-matter, much more is necessary. The teacher, like any other student, should undertake a well-defined and carefully prescribed course. He should begin at the beginning and so far as he goes should do thorough, accurate, connected work. He should attend regularly, study systematically, and from time to time submit his attainments to the test of examination.

The marked success of those teachers who have followed the courses prescribed for the regular students of the Institute has induced the Faculty to consider what special opportunities may reasonably be extended to professional teachers who are unable to undertake a full course.

Two classes of teachers have been especially in view in the preparation of this circular. These are :

First: Those who can obtain a definite leave of absence for a year. The work of the Institute is so arranged that a person of mature mind and good previous training may in that time cover a considerable portion of the elementary scientific work in any

one of several departments. The departments in which one-year courses may thus be taken with the best results are those of chemistry, physics, geology, and biology. Such a course should be complete as far as it goes, and if well planned may become directly available for teaching purposes. Even for those who can obtain leave of absence from their posts for only a half-year, it will be seen by what follows that certain not inconsiderable courses may be successfully pursued in some departments of the Institute.

Second: Those who, while unable to obtain leave of absence, are free for the whole or a portion of their afternoons, and have also at command the whole of Saturday morning. Not a few teachers have found it possible to accomplish much in the Institute laboratories during these brief periods. The officers of the departments of physical and natural science will gladly make arrangements to meet, so far as possible, the convenience of teachers of this class.

In addition to the special courses hereinafter offered there will be a course of lectures, in the second term of the school year, upon the teaching of the elements of science, in which many of the professors and instructors of the Institute will take part.

Teachers have always been admitted to the Institute without examination. It is not proposed to make any change in this particular, but teachers are advised to consult the catalogue of the Institute, under the titles, "Requirements for Admission" and "Special Students." Women are admitted upon the same terms and requirements as men. For information regarding tuition fees inquiries should be addressed to the Secretary, stating the course or courses which the applicant desires to take.

As examples of what may be done by teachers as special students at the Institute, the following statements may be made concerning the departments of physics, chemistry, biology, and geology, showing what teachers of each of the two classes named above may obtain at the Institute in the time at their disposal.

PHYSICS.

Teachers who can spend a whole year at the Institute are advised to pursue the following studies in the department of physics. They are expected to be familiar with algebra, geometry, and plane trigonometry. For the most advanced work, further mathematical study may be desirable.

1. **General Physics** Lectures (second year class), three hours per week throughout the year. This course covers the subjects of mechanics of solids, liquids and gases, light and electricity.

2. **Acoustics and Electricity** Lectures (second year class), two hours per week throughout the year. The subject of acoustics occupies somewhat more than half of the time mentioned, extending a few weeks into the second term. The remaining portion of that term is devoted to a more specific discussion of certain portions of the subjects of magnetism and electricity in connection with Course 1.

3. **Heat** Lectures (third year class), two hours per week during the first half of the first term. For undergraduate students these lectures follow the preceding courses, but a person of mature years and of good training need have no difficulty in taking all simultaneously.

The three foregoing courses of lectures are designed to give a knowledge of the fundamental principles of physics. They are fully illustrated by experiments; and besides the facts and theories of this branch of science, the teacher may gain from them incidentally much valuable knowledge as to the use of apparatus for demonstration in the class room.

4. **Physical Laboratory**, four to twelve hours per week. In these exercises the student works by himself under the guidance of an instructor, proceeding more or less rapidly as he desires. A greater number of hours than is suggested may be given to the subject.

The exercises in the physical laboratory are intended to instruct the student in all branches of physical measurement, to train him in habits of accuracy, and to impart skill in the

manipulation of apparatus. The work is wholly quantitative in its character, and the experiments given are progressively more difficult as the student proceeds. They cover the subjects of general physical measurements, light, heat, and electricity.

Special courses in heat measurement and electrical testing can be pursued by those who are competent to undertake more advanced work.

In connection with the lecture and laboratory courses the student will find it highly desirable to read various special treatises and scientific papers upon the different branches of physics pursued. He will have full access to the physical library, which is of unusual excellence, and will also be guided in his choice of reading by the instructors of the department.

Those who are sufficiently advanced in their knowledge of physics and mathematics on entering may add to the preceding subjects any of the more purely professional studies given to the undergraduate students in physics and electrical engineering, as, for example, the lectures on theoretical and mathematical electricity and those on the technical applications of electricity.

The student may very profitably combine with the courses of exercises in physics, lecture and laboratory instruction in general chemistry (first year class), seven hours per week throughout the year. He will also find it advantageous in his future work to include the analytic geometry and differential calculus of the second year, three hours per week throughout the year.

Teachers who are able to spend one half-year, or less, are advised to take :

1. Such lectures on mechanics, light, acoustics, and electricity as are in progress during the time of their attendance — three to five hours per week.

2. Physical laboratory exercises. Except on Saturday the laboratory will be open to students of the class under consideration continuously from 9 A.M. until 4.30 P.M.; on Saturday it will be open from 9 A.M. till 12 M. Within these limits, as many hours may be spent in this work as the student desires. It is doubtful,

however, whether more than four hours per day can profitably be spent in actual experimentation.

A certain amount of instruction in general chemistry or in mathematics may, of course, be added to the purely physical work suggested above.

Teachers able to give only their afternoons can spend two and one half hours of each afternoon, or of such afternoons as they choose to select (Saturday afternoon excepted), in the physical laboratory. Those who wish to attend only on Saturday morning can spend three hours in the same manner. Such a course of laboratory work, even if occupying only three hours per week during one year, may nevertheless prove of great advantage to the teacher in the active pursuit of his profession. In the past many teachers have taken such a course with profit.

It is not necessary that the student should follow the specific courses suggested in the preceding pages. These are stated as showing what may be done rather than what must be done. The variety of instruction and the extent of the laboratories allow great latitude in the planning of a course which shall meet the individual needs of any teacher.

The equipment of the Rogers Laboratory of Physics in apparatus for laboratory instruction and lecture-room demonstration is a very exceptional one; and the same advantages will be offered to those pursuing the special courses referred to in this circular as to regular students.

CHEMISTRY.

THE following courses in chemistry may be taken by teachers who can devote an entire academic year to study at the Institute :

1. **General Chemistry.** This course includes two lectures and one recitation a week and practice in the laboratory of general chemistry. The lectures, with full experimental illustration, give the fundamental principles of chemical science and a description of the properties of the most important elements and their combinations. The laboratory exercises comprise a long series of experiments, classified under the different elements, designed not only to give the students familiarity with the more important chemical reactions, but also to train them in accurate habits of observation and to give the skill necessary for the successful handling of chemical apparatus.

The course in general chemistry extends over an entire year, and is a necessary preparation for all other courses in chemistry. Mature persons with formed habits of study are permitted, however, to pursue other courses after one term (fifteen weeks) of general chemistry, at the same time that they are completing this course.

There is no limit to the time which may be spent in the chemical laboratories, so that a teacher may, during the first term, cover all the experimental work in general chemistry which is laid out for the regular students for the entire year.

2. **Qualitative Analysis** may be begun in the second term. It is taught by systematic class-room exercises and by laboratory practice. The amount and variety of the work will depend mainly on the time which the student can spend in the laboratory. The course begins with the analysis of simple chemical compounds, and gradually progresses to the analysis of substances of considerable complexity, such as natural minerals and industrial products of various kinds.

3. **Quantitative Analysis** may be carried on at the same time as qualitative analysis. There is no necessary sequence in these two kinds of analysis; and it is only a matter of convenience in

teaching that provides usually for the completion of the course in qualitative analysis before quantitative is begun. The methods of quantitative analysis require a considerable amount of time in order to insure accuracy, and consequently the ground covered in one term cannot be large. But the principles of gravimetric and volumetric analysis can be taught in one term with a fair amount of laboratory practice in the quantitative analysis of simple substances.

4. Theoretical Chemistry. A certain amount of instruction in the laws of chemical action is necessarily given in connection with the lectures on general chemistry. But in addition to this there is a course of thirty lectures and recitations in theoretical chemistry, which treats of modern chemical theory with great thoroughness. This course should be taken by all who intend to teach chemistry.

5. Organic Chemistry. There is a short course of fifteen lectures on the elements of organic chemistry, which can be advantageously taken by teachers whose limited time or imperfect preparation precludes their taking the more extended course on this subject.

These five courses in chemistry — namely, general chemistry, with laboratory practice, theoretical chemistry, and short courses in organic chemistry, and in qualitative and quantitative analysis — can all be taken advantageously in one year by teachers who have no previous knowledge of chemistry. For those who have already gone over some of this ground, the year's work can be so arranged as to give more time to those subjects which have not been previously studied. Thus the amount of work in quantitative and qualitative analysis may be much increased in case one is thoroughly familiar with laboratory practice in general chemistry.

In cases where a whole year cannot be given to study at the Institute, the selection of courses in chemistry will depend on the amount of previous preparation. For instance, the study of qualitative analysis could not be begun without a fair knowledge of general chemistry and of the use of apparatus. The first term of

the Institute year — October to January — can always be profitably employed by beginners in the study of general chemistry with its accompanying laboratory practice. Those who have no knowledge of chemistry will not find it profitable to begin their studies in the second term.

For those who can spend only one day in the week at the Institute the work must be limited to laboratory practice in those subjects for which the student has the necessary previous knowledge. In any case, whether a teacher desires to devote one day a week or an entire year to the study, the intelligent planning of a course which will give the most profitable and satisfactory results can best be done with the assistance and advice of the head of the department.

It will also be found generally profitable, by those taking chemical studies, to add, if time permits, courses in allied subjects, such as physics, mineralogy, microscopy, etc.

Teachers who are more or less proficient in general chemistry and in qualitative and quantitative analysis and are prepared to profit by advanced instruction, may take the courses in sanitary chemistry — the analysis of water and air, and of food products, such as butter and milk; industrial chemistry, a course of sixty lectures, accompanied by laboratory practice in the manufacture of chemicals on a large scale from crude products; assaying of ores of the precious metals; gas analysis; the optical analysis of sugar; textile coloring; advanced theoretical (physical) chemistry; organic chemistry and organic analysis. By those who are fitted for the work, original investigations may be conducted in any department of chemistry.

BIOLOGY.

IN biology, including zoölogy, botany, physiology, comparative anatomy, embryology, and bacteriology, the following courses may be taken by teachers:

By those who can spend an entire year at the Institute —

1. **General Biology.** This course is intended as an introduction to the whole range of plant and animal life. It bears to the biological sciences much the same relation as general chemistry and general physics bear to the chemical and physical sciences.

As now arranged, the course in general biology begins in the first term, and consists of two recitations, or lectures, and three hours of laboratory work each week for the fifteen weeks of the term. It is not merely a course for beginners, though many beginners take it; it is found to be useful, also, for those who desire a broad training in the fundamental facts and principles of biology—with practice in laboratory methods. During the course a representative plant and a representative animal are thoroughly and minutely examined, while the essential chemical and physical basis of living things is constantly emphasized. Microscopes are furnished and careful drawings are required. Abundant material is provided without extra cost, and the elementary technique of microscopy, dissection, and microtomy is readily acquired. The biological laboratory is always open, and every facility is granted to those who are fitted to avail themselves of extra laboratory work.

2. **General Zoölogy.** Following the course in general biology is a second term course in general zoölogy. In this a rapid survey is made of the whole animal kingdom in fifteen two-hour lectures, accompanied by demonstrations and the actual handling of specimens. A peculiarly rich collection of charts assists the student in gaining a general view of animal life, the outlines of classification, and the principal facts of anatomy and of distribution. Here, also, teachers already familiar with the subject may pursue special work, with ample opportunities for making dissections and drawings under advice and direction.

3. **General Botany.** Parallel with the course in general zoölogy is a brief course in general botany. This consists of fifteen exercises, or one hour a week, devoted to a survey of all plants, from the lowest to the highest. The course includes a brief consideration of the structure and classification of the plant world, and ends with a few lessons in systematic botany and plant analysis. Abundant opportunity is provided for those who can give extra time to their work.

4. **Comparative Anatomy** is begun in the fall term, and is intended chiefly as a preparation for physiology. It is given by two hours of recitations, or lectures, and six hours of dissection and drawing weekly, and extends throughout the whole first term and one half of the second term, after which time it gives place to embryology.

The course begins with the study of the protozoa, to which considerable time is given, passes on to the sponges, polyps, echinoderms, worms, crustacea, insects, fishes, amphibians, etc., and ends with the anatomy of mammals. The situation of Boston upon the coast is especially favorable for work in the comparative anatomy of invertebrates.

5. **Cryptogamic Botany** is taught in the second term by a series of lectures and practical laboratory exercises. The course requires attendance upon two recitations, or lectures, and three hours of laboratory work each week for the second half-year; and allows, so great is the range of forms accessible for study, a considerable amount of extra work for those who desire it. The diatoms, algæ, fungi; the fission plants, moulds, lichens, mushrooms, puffballs, seaweeds, yeasts, and bacteria; liverworts, mosses, ferns, and the higher flowerless plants, are considered and actually studied in the laboratory.

6. **Embryology.** As the key to the interpretation of many adult structures and functions, embryology is almost indispensable; and for those unfamiliar with it the course in the embryology of the chick, given in the last quarter of the year, is especially recommended. The development of the complex vertebrate body from a microscopic and comparatively formless mass is traced step by step in the hen's egg, and followed by sections and microscopic preparations. It is not too much to say that no one is fitted

to teach anatomy or physiology who has not acquired at least the elements of embryology through tracing out the development of some animal.

7. Anthropology. The course in this subject consists of fifteen one-hour exercises (lectures or readings) upon the relation of man to the lower animals; the evidences of the antiquity of man; craniology (including craniometry); prehistoric man; and the races of mankind. The lectures are given in the fall term.

8. Animal Physiology. In this important subject, now required by law in the schools of most of the States, there are two distinct courses.

(a) A course covering an entire year and requiring as the necessary preparation a good knowledge of comparative anatomy and embryology, and

(b) A course covering a half-year with less severe requirements.

The latter comes in the fall term, and may be taken with advantage by many teachers. It consists of fifteen two-hour exercises, and includes demonstrations, dissections, and conferences. The former extends over the whole year, and requires at least eight hours a week. It covers the whole field of physiology, with constant work in experimental physiology and chemical physiology. The physiology of blood, muscle, and nerve, of the vascular mechanism, and of the tissues of chemical action, occupies the first term, the remaining portions of the subject being considered in the second. For work in this subject the laboratory is well equipped with special apparatus.

Those who take this course should pursue at the same time —

9. Microscopic Anatomy (Histology). This also extends throughout the year, requiring a very large amount of laboratory work in section-cutting, staining, and drawing. In it the minute anatomy of the principal tissues, nerve, muscle, epithelium, connective tissue, and the principal organs is worked out.

10. Bacteriology. In this subject an advanced course is given, chiefly to those who desire to become specialists. For educational purposes, however, the advantages of the study of bacteriology are very great, owing to the nicety and care required.

The course comes in the fall term, and requires four hours a week, three of which are given to laboratory work.

11. Theoretical Biology. This consists of thirty lectures and conferences, one a week throughout the year, in which such subjects as heredity, variation, natural selection, Darwinism, etc., are discussed and criticised. It is believed that for teachers, who are already prepared for it by a thorough knowledge of zoölogy, botany, embryology, and anatomy, this course may be of great service.

12. History of the Inductive Sciences. Few teachers are familiar with the history of the subjects which they teach. Even the names of the founders of chemistry, physics, zoölogy, botany, anatomy, physiology, etc., are unknown to many who are familiar with the results of their labors. For such persons this course, consisting of fifteen lectures (with collateral reading) upon the history of the inductive sciences, should prove very helpful. It is given in the fall term.

13. Microscopy. For beginners in work with the microscope this course serves as an introduction. It comes in the spring term, and consists of fifteen two-hour exercises of practical laboratory work with the microscope, of which the construction, theory, and operation, as well as the more common applications, are fully explained.

For those who cannot give an entire year to work in the Institute, but only one half-year or even less, a perusal of the foregoing pages will show that much may still be done.

Owing to the poor light of the autumn and winter afternoons, and the great importance of the best light for nearly all kinds of biological work, it is not advisable, as a rule, for teachers who can give only their afternoons to undertake biological studies in the autumn. Saturday mornings, on the other hand, may be made to yield excellent results; and the difficulty just referred to does not exist in the second (or spring) term.

The officers of the biological department will always be glad to give special advice in particular cases. As a rule, teachers will find it to their advantage to combine with their biological work courses in chemistry, physics, mineralogy, geology, mathematics, history or philosophy, such as those described in this circular or laid down in the catalogue.

GEOLOGY.

To those teachers who desire to devote a year to study with special reference to geological work, the Institute affords the following opportunities :

FIRST TERM.

1. **Structural and Chemical Geology** :—A course of three lectures each week is given. The principal structural features of large masses of rock are taught as concretely as circumstances will allow, and specimens are freely used in the class room. A series of lessons in the field is given in connection with this course. In the systematic study of rocks a large amount of observation and of laboratory work is done. Each student has a tray, containing typical specimens of each type to be studied ; and the lessons consist largely in the examination, testing, and description of the specimens themselves. In chemical geology, the formation, alteration, and decay of rocks, the origin of vein stones, ore deposits, etc., are taught in a similar manner. The course includes a discussion of the early chemical history of the earth.

2. **Structural Paleontology** :—The course of laboratory exercises, occupying two hours each week, is available for teachers who have been sufficiently prepared by study in zoölogy.

3. **Climatology** :—A course of two lectures each week, which teachers have found heretofore very helpful. It deals with the various components of climate, as temperature, moisture, storms, etc., with frequent discussion of the effects exerted by climatic conditions upon the growth and distribution of plants and animals, and upon commerce, industry, and health.

4. **Economic Geology, Physiographic Geology, and Micro-Lithology** :—For those who are prepared for the work, there are advanced courses in these subjects.

SECOND TERM.

5. **Mineralogy and Blowpipe Analysis** :—During this term students have an opportunity for the study of these subjects with practice, occupying six hours per week. In descriptive miner-

alogy the student is constantly using specimens which he is taught to identify by their crystallization and physical properties as well as by blowpipe and chemical tests. The arrangement of the laboratories and the method of instruction make this course a thoroughly practical one, in which students acquire considerable familiarity with specimens.

6. **Physical Geography**:—A course of three lectures each week, in which it is the constant aim to teach scientific geography as adapted to the wants of students in a technical school. The course is amply illustrated, and affords teachers opportunity for an advanced study of this subject.

7. **Historical Geology**:—The course occupies three hours a week with lectures and recitations.

8. **Geological Maps and Sections**:—A course in the construction of maps and sections is begun with field work and completed in the laboratory.

9. **Structural Paleontology** is continued through this term.

Students who are properly qualified may continue their work in economic geology and micro-lithology, and a course in ore deposits is also given. If sufficiently prepared, teachers may enter a course with fourth year students in the Institute for the purpose of reading selected geological memoirs and discussing the subjects there presented under the direction of the professor in charge.

The geological library and laboratory are so arranged that special work may be assigned and opportunities afforded for pursuing lines of study which shall meet individual requirements.

LITERATURE, HISTORY, AND POLITICAL SCIENCE.

IN addition to the courses offered by the departments of physics, chemistry, biology, and geology, the professors in the General Course of the Institute are prepared to give special facilities for study in literature, history, and political science, to teachers who can devote a year, or even less time, to work at the Institute. The following are some of the courses offered :

ENGLISH.

FIRST HALF--YEAR.

1. **English Literature**, "Beowulf" to Shakspeare.
2. **English Literature in the 19th Century.**
3. **Contemporary English and American Literature.**

SECOND HALF--YEAR.

4. **English Literature in the Age of Elizabeth.**
5. **English Literature in the 19th Century.**
6. **English Composition (Advanced Course).**

HISTORY.

For teachers who can attend throughout one year the following courses are recommended :

1. **The Political History of England and the United States.** First term, three hours weekly; second term, two hours weekly. Primarily a history of the development of political parties in both countries, emphasizing the continuity of political life and thought in this country with the life and thought of England.
2. **The History and Literature of the Renaissance and Reformation.** Two hours weekly for one year. A study of church and state in mediæval Europe with a concurrent view of literature and the arts from Dante to Lessing.
3. **Comparative Politics.** Three hours weekly for one year. A comparative study of political systems and philosophies, and of modern constitutions.
4. **History of the 17th Century.** Topical reading courses under direction, continuing Course 2.

5. **History of the Era of the French Revolution**, continuing Course 4.

6. **Local United States History**. A reading and thesis course, under direction.

7. **Social Science and History**. Second term only; two hours weekly. A study of institutional beginnings involving the history of origins of family, church, and state.

8. **International Law**. Second term only; two hours weekly. A study of modern diplomatic history, based primarily upon the history of the foreign relations of the United States.

Teachers who can be present only during afternoons or on Saturday mornings may take Courses 4, 5, and 6 to advantage. They may also profit by the reference and thesis work of any of the other classes. Class work in Courses 7 and 8 may be secured in the afternoons. Work in Course 7 is greatly facilitated by previous familiarity with the work in anthropology as given by the Department of Biology.

Every historical class in the Institute has its own selected reference library. The reading room is near the lecture rooms of the department, and both periodicals and books can be used by the student without restriction or delay. The students have the advantage of carefully prepared syllabuses of readings and lectures.

ECONOMICS AND STATISTICS.

THE courses in Economics and Statistics may be of value to teachers from two points of view: (1) for the method employed in the presentation of these subjects; and (2) for the information acquired.

In the instruction in Economics special stress is laid upon the desirability of introducing the student at an early stage to independent and even original work; and experience has satisfactorily shown that the collection, tabulation, and presentation of statistical data relating to the various economic studies form a useful agency for holding the student to individual inquiry, and that they also offer an effective method of testing the qualities of accuracy, discrimination, and honesty on the part of the investigator.

The courses in Economics mentioned in the catalogue cannot be taken except by teachers able to devote forenoons, either for the year or for one term. It is believed, however, that teachers who wish to review or enlarge their methods of instruction will find one or more of the courses in Statistics of practical assistance, and that these will prove suggestive in many directions not outlined in the preceding statement. As instruction in these subjects is very largely of a personal character, arrangements can generally be made to suit the time and needs of the applicant.

There are three courses in Statistics :

1. **Chart and Map-Making**, which is given by the Department of Drawing, in the second term. Instruction is given in technical execution, tinting, preparing drawing paper, crosshatching, use of the pantograph, making of historical maps, etc. This course may be taken afternoons, and may be made very elastic, to suit the individual needs of the students applying.

2. **American Statistics**. This course is given in the first term, and is treated as a method of education rather than as an end in itself. The student is shown how to use public documents, discover facts for himself, and prove or disprove statistical statements. The use of census documents, finance reports, etc., is included. This course, also, may be taken in the afternoons, and may be adjusted in point of time to individual needs.

3. **Statistics of Sociology**. This includes a considerable amount of descriptive matter in regard to the movement of the population and its sociological characteristics. The student is introduced to the discussion of criminal, moral, and vital statistics, and much stress is laid upon independent research. There is a large amount of sociological material in town and city reports which is capable of personal treatment by students of the high school grade, if intelligent direction is given to their efforts. Work of this character is of great advantage in encouraging students to habits of investigation. This course is given in the first term, and, if due notice be given, may be taken up in one or more afternoons and on Saturday mornings.

The Library and Reading Room of the Department of Economics is well equipped and is always accessible to students.

